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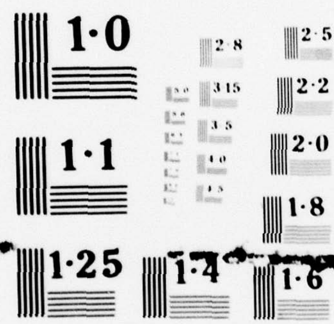

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EXPERIMENTAL INVESTIGATION OF THE BASE PRESSURE ON ROUND CYLINDERS OF LARGE ASPECT RATIO

By

V. M. Kovalenko, V. S. Kosorygin, V. V. Shumskiy

FOREIGN TECHNOLOGY DIVISION

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By: V. M. Kovalenko V. S. Kosorygin, V. V. Shumskiy

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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EXPERIMENTAL INVESTIGATION OF THE BASE PRESSURE ON ROUND CYLINDERS OF LARGE ASPECT RATIO

V. M. Kovalenko, V. S. Kosorygin, V. V. Shumskiy

Behind the blunt base of a body of revolution, located in a supersonic gas flow, rarefaction appears. The degree of rarefaction determines the amount of base resistance - one of the components of total resistance of the body.

As is known, base pressure depends primarily on the condition of the boundary layer at the point of separation and in the region between it and the point of attachment, located on the axis behind the base section. Furthermore, it depends on the angle of attack, the shape of the body on the whole and, in particular, the configuration at the foundation, on the aspect ratio of the body, condition of its surface, on the main parameters of incident flow - Mach and Reynolds numbers, wall temperature. At present there are experimental data

about the effect of different factors on the base resistance of bodies of revolution [1]. None the less these data do not always make it possible to sufficiently reliably calculate the value of base resistance, particularly in those cases when the shape of the examined body substantially differs from the versions for which the experimental data are obtained. For example, the existing experimental results and emperical formulas, evaluating the effect of elongation on the amount of base pressure, are obtained only with moderate aspect ratios ($\lambda \leqslant$ 18-20). In practice bodies of revolution are applied, for example meteorological rockets, with aspect ratios double the indicated range. The most reliable in such cases remains the method of direct measurement of the base pressure.

The experimental investigation of base pressure is conducted on three models of bodies of revolution of moderate and very large aspect ratio. The models represent a combination of a cylinder and ogive with a spire (Fig. 1).

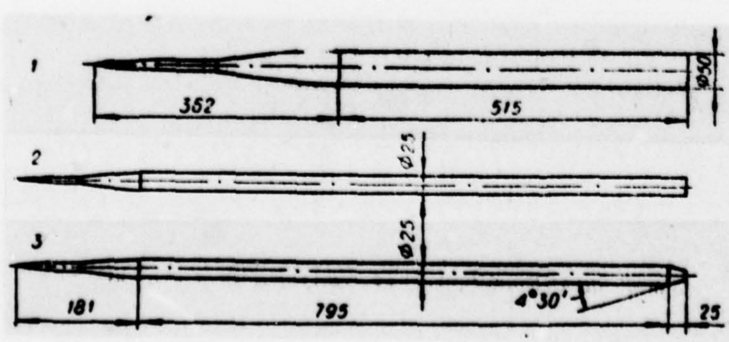

Fig. 1

Fig. 1. Aerodynamic arrangements of models.

The cylindrical part had aspect ratio λ_n = 10.3 (model 1) and 32.8 (models 2 and 3). Model 3 differed from model 2 by the prasence of back tail cone.

The tests were conducted in a supersonic wind tunnel with dimensions of working area 0.6 X 0.6 m^2 at M numbers 3 and 4; Re_{1M} numbers were $36 \cdot 10^6$ and $54 \cdot 10^6$ respectively.

Attachment of the models to the a-mechanism of the tunnel was accomplished with the aid of an arrow-like side holder (Fig. 2).

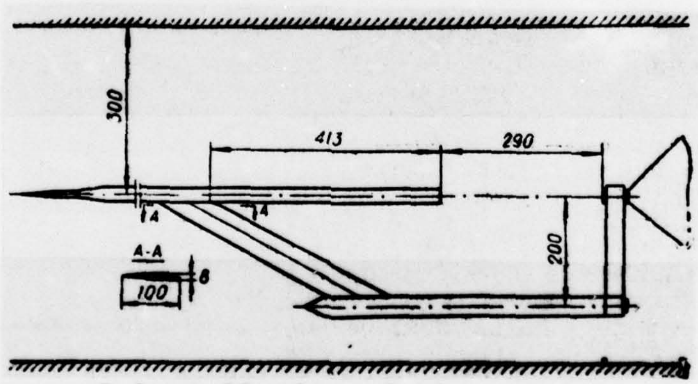

Fig. 2. Diagram of installation of the model in the wind tunnel.

The small diameter of the base section of the models (25 and 20.9 mm) eliminated the possibility of application of a tail holder. The end part of the side holder had cylindrical shape, its diameter was equal

to the diameter of models 2 and 3. All the models were sectional. The tail part of the models were fastened to the end cylindrical part of the side holder with the aid of a pneumatic joint and coupling bolt. This gave the possibility of testing all the models on one holder.

For decrease of the effect of the side holder on the base pressure its thickness was selected the minimum possible from conditions of strength. For increase of the rigidity of the system model-holder relative to axis Y, which has significant value at the moment of start of the tunnel, the model was additionally fastened with the aid of two wire braces 0.8 mm in diameter, going from the base of the spire to the windows of the tunnel.

The base pressure was measured in two mutually perpendicular sections. The construction of the base part of the model made it possible to turn the rows of drainage holes around the axis of the model within +-45° with 15° pitch. For measurement and recording of the pressure group recording pressure gauges (GRM) were applied with limits of measurement +-1000 kg/m² (precision class 0.5). Then pressure coefficients were computed

$$\bar{p}_i = \frac{p_i - p_\infty}{q_\infty},$$

were p_i - pressure in i point of the bottom section; p_∞ - static pressure of undisturbed flow; q_∞ - dynamic pressure. The pressure

distribution obtained in tests turned out tc be virtually constant along the diametral sections of the base section with change of relative radius $\bar{r}$ from 0 to +-0.93 and not depending on angle ϕ (angle of plane of measurement with plane xz, Fig 3).

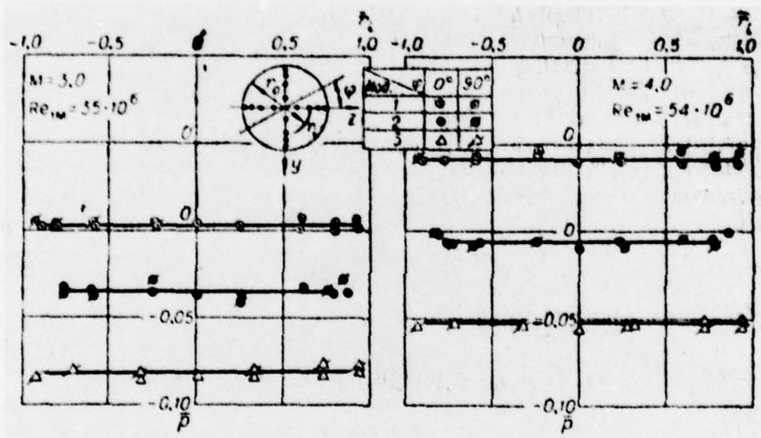

Fig. 3. Distribution of coefficient of base pressure along the bottom of the model.

These data are confirmed by the results of measurements of base pressure presented in [2] with the presence of turbulent boundary layer at the point of separation.

With $|\bar{r}|>0{,}93$ the pressure coefficient $\bar{p}_i$ with respect to absolute value, apparently, is decreased. If we take $\bar{p}_i$ constant along the section with $0<|\bar{r}|<1$ and equal tc its average value $\bar{p}_{cp}$

with $0 \leqslant |\bar{r}| \leqslant 0.93$, then the coefficient of base resistance

$$C_{x\text{д}} = -\bar{p}_{\text{ср}}\bar{S},$$

where

$$\bar{S} = \frac{S_{\text{дн}}}{S_{\text{мод}}}.$$

Fig. 4 shows experimental values of $C_{x\text{д}}$ for three models.

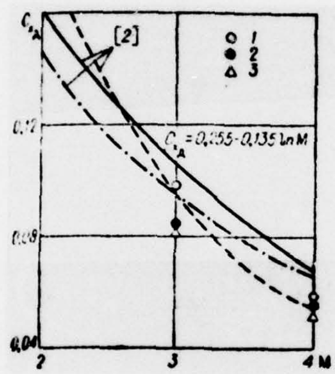

Fig. 4. Coefficient of base resistance. Comparison of experiment (models 1-3) with data of work [2].

With moderate aspect ratios they agree well with the data of other works [2]. Increase of the aspect ratio of the cylindrical part $\lambda_{\text{ц}}$ from 10.3 to $\lambda_{\text{ц}}$ = 32.8 leads to decrease of the base resistance at M = 3 and 4 respectively by 12 and 6 o/o, i.e., with increase of M number of incident flow the effect of aspect ratio becomes less significant. This result qualitatively agrees with the physical concepts about the method of base pressure and is confirmed by data of Fig. 5, on which is seen the effect of dimensionless thickness of

the boundary layer on the base pressure with different M numbers (according to work [1] and our tests).

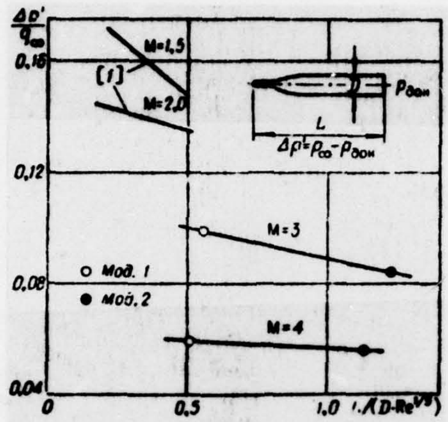

Fig. 5. Relationship between the magnitude of base pressure and dimensionless thickness of the boundary layer.

Let us note in conclusion that the presence of a tail cone (model 3) decreases the absolute value of the coefficient of base pressure approximately 5 o/c.

Institute of theoretical and applied mechanics of SO AN USSR, Novosibirsk.

Submitted Mar. 16 1972.

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